

Artificial Intelligence: An Evolving System of Synergy Between Science and Sign Language

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Abstract

Artificial Intelligence, or AI, is a scientific breakthrough of the world today, as it is changing several realms in human life, such as education, healthcare, and communication. Among the most important spheres, in which AI also proves its opportunities, the sign language is mentioned, which is the main way Deaf people communicate. The dynamic collaboration between AI, science and sign language shows how scientific innovation can go beyond the technical scope of implementation to ensure inclusiveness, equity and universal access to communication. This paper discusses how AI can be used as an intermediary between science and sign language, and includes examples of its use in gesture recognition, translation systems, and real-time accessibility tools. It further discusses the educational, ethical and social aspects of this synergy and the significance of technology in lessening communication barriers among people with hearing impairment. The paper has concluded that the implementation of AI with sign language is an indicator of a new paradigm of scientific advancement, a paradigm guided by inclusiveness, empathy, and human-centered growth.

Keywords: AI, sign language, science, education, healthcare.

Introduction

Artificial Intelligence (AI) is now considered to be one of the most prominent scientific

breakthroughs of the 21st century, spreading its impact over education, healthcare, communication, and industry. In contrast to

traditional scientific frameworks, operating within strict limits, AI is a flexible and changing structure, which learns, gets adapted, and emulates human intelligence using data-driven models. Its use extends beyond efficiency and productivity to deal with systemic problems of inclusiveness and accessibility. The most important linguistic system of Deaf communities, sign language, was historically marginalized by both the science and society, as there are certain misconceptions about the superiority of spoken and written languages. The introduction of AI into the study and practice of sign language is however changing this perception and is making sign language a structured, rule-based means of communication deserving scientific interest (Adebisi & Odetunde, 2023). This is a huge change in which science is not only about discovery but also extending knowledge to social realities.

The applicability of AI to sign language is even more evident when the latter is considered through the lens of communication as a human right. Systemic barriers have long been a problem affecting deaf people in the fields of education,

employment, and healthcare since the mainstream communication systems did not serve them adequately to meet their linguistic needs. The role of science in these obstacles is historical as it has ignored minority languages, thus supporting exclusion. Nowadays, AI provides a way of inclusiveness and facilitates tools like sign-to-text translation and speech-to-sign recognition as well as avatars-based interpretation. Oladipo and Ibrahim (2024) state that scientific innovations that do not fit the needs of the disadvantaged populations cannot be said to be holistic. The use of AI in sign language shows that science, with the focus on inclusivity, transforms into a synergy system, where human communication is the primary concern, as well as technological progress. This makes AI not a mere computational innovation but one that is a social equalizer.

The introduction of AI to sign language has tremendous implications in the Nigerian context. Nigeria is a country with a multicultural language situation, with the Deaf population using Nigerian Sign Language (NSL) as their communication means in their everyday life. Regrettably,

NSL has not been represented enough in education and technological systems, thus left Deaf students out of equal learning opportunities, especially in Mathematics and Science subjects. According to Eze and Lawal (2022), without incorporating supporting technologies that help make education more accessible, it is impossible to achieve inclusive education. The answer to this challenge is an innovative solution to the challenge by the development of platforms through which teachers and students can interact effectively irrespective of hearing capabilities. This is a development that guarantees inclusion and at the same time enables Deaf learners to participate positively in learning settings. In this regard, AI is reconstructing the role of science in education by making the learning systems fair and accessible to everybody.

Outside the classroom, the combination of AI and sign language transforming society as a whole, as it builds inclusivity in healthcare and in the work environment. To illustrate, AI-based solutions in hospitals may be used to assist Deaf patients to effectively communicate with medical staff about their symptoms and avert misdiagnosis and

improve health outcomes. Correspondingly, the work environment that implements AI-based sign recognition may boost the interaction between Deafs and hearing workers to increase productivity and participation. Musa and Adeniran (25) state that inclusive technologies like AI are socially necessary as well as economically strategic, as they utilize the skills and input of marginalized populations. These uses underscore the changing nature of science as a pragmatic instrument of meeting human requirements, and not as an abstract endeavor within laboratories. Incorporating inclusivity in the scientific practice, AI reinforces the social cohesion and enhances equity.

Ethical issues surrounding the introduction of AI into sign language systems that bring up the question of the role of science that is changing. Okafor and Akinyemi (2023) argue that science should be ethical and capture the values of humanity, which must make advancements to the common good of all communities, and particularly that which are historically marginalized. The establishment of sign language as a system subject to computation reaffirms the right of the Deaf community to its full inclusion in

society, and eclipses the historical injustices.

Therefore, AI is not only the embodiment of the technological advancement but the re-invention of science as a non-discriminatory and compassionate project. The convergence of AI, science, and the sign language, thus, suggests a radical transformation of the elitist approaches of innovation to people-centered development. It highlights the point that genuine scientific advancement should not be evaluated only in terms of intellectual success but also in terms of its ability to increase equity, accessibility and human dignity.

Synergy between Science and Sign Language through AI

The dynamic scientific and sign language mutualism via AI demonstrates the inter-disciplinarity of the contemporary innovation. Empirical studies which are concerned with the increase of knowledge have been a part of science, whereas sign language has frequently not been regarded as a valid linguistic system. This is a perception that is changing with the introduction of AI. The neural networks, deep learning models, and computer vision technologies have proved that sign language may be processed

by a computer and translated into text or speech. This progress proves that sign language is a scientifically complex rule-based system. Oladipo and Ibrahim (2024) emphasize in Nigeria that marginalized languages, like the Nigerian Sign Language, have to be incorporated in technological innovation to allow the full inclusion in social and academic life. In that way, AI is turning science into a purely knowledge-driven endeavor and a system capable of closing the communication gaps that exist between humans to introduce marginalized populations into the mainstream of societal development.

The combination of science with sign language via Artificial Intelligence (AI) portrays how new innovations are not necessarily aimed at technical objectives, but at human-focused creation. Science has traditionally been thought of as a field of objectivity and discovery and sign language was usually pushed aside and considered to be peripheral to linguistic and social research. This perception is evolving as AI is becoming more widespread. Neural network systems and machine learning systems have shown that sign language has complicated grammar

and semantic representations which are computationally models. Adetunji and Bakare (2023) observe that the introduction of sign language into AI can be explained as the science developing as it embraces diversity in communication systems. This synergy shows that the role of science is not limited to laboratories anymore but it is the one that promotes inclusivity through the validation of marginalized languages.

It is also significant how the involvement of AI in the work of sign language creates interdisciplinary interaction. The scientific concepts of AI models include physics, mathematics, computer science, and cognitive linguistics that combine to form systems that can identify hand gestures, facial expressions, and body orientation. As an example, deep learning algorithms trained on vision-based AI models now have the capabilities to recognize the subtleties of sign language and translate it to written or spoken language. In Nigeria, according to Bello and Ahmed (2024), such technological developments are crucial in assisting to lower educational disparities in Deaf students who utilize Nigerian Sign Language (NSL). This interdisciplinary characteristic of the given

innovation indicates that science is best applied when the various disciplines can be brought together so that they can deal with real issues of humanity. This turns AI not only into a technological but also a scientific instrument of social change.

The synergy also shows the democratizing aspect of science being used by AI. In the past, science has been accused of benefiting majority communities and ignoring the minority groups. The AI systems have, however, opened up new ways of being more inclusive since Deaf people can now communicate better in various environments. The use of digital sign recognizers, sign to speech translators, and AI-powered avatars are some of the ways that inclusivity is being integrated into scientific innovation. Evidence of science being made more democratized and responsive to social realities is that technologies increasing the accessibility of marginalized populations are provided, as Olayemi and Nwosu (2022) state in their argument. Incorporating sign language into AI, science confirms that science is applicable to every member of the society, especially those who have remained

marginalized in the past in the mainstream communication.

The ethical aspect of this synergy is also to be considered, because it points out the moral accountability of science. The idea of sign language inclusion in AI technologies has not only to do with innovation but also equity and justice. Danjuma and Oladiran (2023) argue that ethical innovation in Africa should focus on inclusivity in case it can be used to benefit sustainable development. Sign language interpretation AI systems represent this ethical obligation as they guarantee that Deaf people have equal opportunities to attend schools, hospitals, and workplaces as hearing people. The synergy thus re-defines scientific advances as an ethical project with accessibility and human dignity in the center of technology design. In this regard, AI emerges as one of the channels that science can coincide with the values of fairness, inclusivity, and social justice.

AI application to the sign language in Nigeria on the local level was developed to illustrate how international innovation can be localized. Although much AI breakthroughs are based in developed countries, Nigerian researchers and innovators are now starting

to come up with localized AI that have integrated Naigerian Sign Language into communication systems. Such local applications, which Adeyemi and Ogundele (2025) observe are important to close the digital divide and reach national objectives in education and employment. This is a part of a larger pattern in which science, with the help of AI, functions on a global and local level so that technological advancement is sensitive to the realities of various communities. Science-sign language synergy is therefore seen as an example of how innovation can be inclusive, adaptable, and sustainable such that all populations are not left behind in the global knowledge economy.

Scientific and Educational Implications

The implication of AI to sign language is that it has wide-ranging effects on education. The scientific advances in gesture recognition and translation in real-time will enable the creation of AI-based applications that can facilitate teaching and learning in Deaf students. These systems will help in overcoming communication barriers between teachers and learners especially in Mathematics and Science subjects where abstract concepts are usually challenging to

express. Eze and Lawal (2022) state that inclusive education presupposes the use of technologies that will allow equal access to learning materials. The use of AI in education evidences the way in which science could be both a theoretical and practical resource to lessen the disparities. As an example, AI sign language avatars can discern lectures, and capturing software makes virtual classrooms more accessible. Not only do these innovations make education more inclusive, but they also make the science a vehicle of social justice, since the students with hearing impairments will not be denied access to academic opportunities.

The science of Artificial Intelligence (AI) regarding sign language has immense implications on science, especially the broadening of the horizons of understanding human communication. The conventional study of linguistics has been aware of the complexity of sign languages, but AI enables scientists to study them in more detailed computational and neurological terms. With the advent of machine learning and natural language processing (NLP), signs researchers are now able to study the syntax, morphology and pragmatics of sign languages in a more

detailed manner. Igbokwe and Adeola (2023) argue that this contributes to the scientific perspective of the functionality of human languages outside speech, which supports the assertion that sign languages are not inferior to spoken languages but they are equal. These observations do not only contribute to the field of linguistics but also overlap with other fields of study such as cognitive science, neuroscience, and computational modeling to have a holistic understanding of the human communication systems.

Applications of AI in sign language can be used in education to provide revolutionary opportunities on inclusive pedagogy. A high number of Deaf students experience an impediment to mainstream education as a result of the low level of interpretation services and insufficient teaching resources. Sign-to-text translators, intelligent tutoring web platforms, and real-time captioning platforms are examples of AI-based tools that alleviate these issues. Eze and Mohammed (2024) underline the idea that the tools result in the improved participation in classroom activities and enable Deaf students to learn alongside hearing students. In addition to accessibility, AI promotes differentiated

instructions, where teachers can customize the materials to suit the special learning requirements of hearing-impaired students. This is in harmony with educational priorities in the world community in the form of Sustainable Development Goals (SDG 4) that promote inclusive and equal quality education to everyone.

The other important educational implication is on the teacher professional development. To successfully integrate AI into the classroom, educators must be trained on the technical side of AI tools as well as on how to use AI to effectively teach Deaf students. According to Okeke and Salisu (2022), teacher education should also be changed to produce teachers who will be able to use AI-based sign language applications in the classroom without any hesitation. These kinds of training enable teachers with the ability to close the communication gaps, and create inclusive learning situations. In addition, it transforms the roles of the teacher as a purveyor of knowledge to interactive and technology-driven learning. This change is a wider trend in the area of educational science in which intelligent systems complement human knowledge, but not substitute it.

The scientific implications of AI also extend to curriculum development and educational policy. Curriculum planners and policymakers can leverage AI-generated data on Deaf students' learning progress, strengths, and challenges to design more evidence-based programs. According to Nwachukwu and Dania (2025), data analytics from AI platforms provide insights into learning patterns that were previously inaccessible, enabling educators to refine curricula in mathematics, science, and other core subjects. For policymakers, these insights support inclusive education reforms by highlighting gaps in resources, teacher preparation, and accessibility infrastructure. By institutionalizing AI-supported strategies, governments can ensure that Deaf students are not marginalized within national education systems but are given equal opportunities to thrive academically.

The implications reach beyond education into social and economic empowerment, which indirectly feeds back into scientific development. Educated Deaf individuals who benefit from AI-enabled learning become contributors to scientific and technological fields themselves, thereby diversifying

perspectives in innovation. Adebajo and Yusuf (2023) note that empowering marginalized groups through inclusive education produces a ripple effect in national development, as more citizens participate in scientific research, technological industries, and creative problem-solving. This transforms AI from being a tool of assistance to a catalyst of empowerment, ensuring that the Deaf community is not only a beneficiary of science but also an active contributor. Thus, the synergy between AI, science, and education strengthens inclusivity while advancing human knowledge and societal development.

Ethical and Social Dimensions

Beyond its technical applications, the synergy between AI, science, and sign language raises important ethical considerations. The inclusion of sign language in AI systems demonstrates a commitment to equity and social responsibility in scientific progress. If AI systems ignore minority languages, including sign language, they risk deepening existing social inequities. According to Okafor and Akinyemi (2023), ethical science must be responsive to the needs of marginalized

groups in order to remain relevant in contemporary society. Developing AI-driven sign language systems is therefore not just a technical exercise but also a moral obligation. By making communication inclusive, AI aligns scientific discovery with principles of justice, fairness, and empathy. This ethical alignment strengthens the argument that true scientific progress must be measured not only by its innovation but also by its impact on human dignity and accessibility.

The ethical dimensions of integrating Artificial Intelligence (AI) with sign language largely revolve around fairness, inclusivity, and accessibility. While AI has the potential to reduce communication barriers for the Deaf, there are concerns about whether these innovations are designed in ways that truly respect their linguistic and cultural identity. According to Okon and Ibrahim (2023), AI systems often prioritize global sign languages like American Sign Language (ASL) at the expense of regional ones such as Nigerian Sign Language (NSL), raising questions of linguistic justice. This imbalance suggests that without deliberate inclusion, AI may reinforce existing inequalities rather than eliminate them. Thus,

ethics demands that AI developers adopt participatory design approaches, involving Deaf communities in the creation and validation of such tools to ensure that their needs and identities are respected.

Another ethical consideration relates to data privacy and consent in the development of AI systems. The creation of sign language recognition tools often requires massive amounts of visual data, including videos of Deaf individuals communicating. If not properly managed, such data could expose individuals to risks of surveillance or exploitation. As Adebayo and Chukwu (2022) argue, ethical AI must prioritize informed consent, secure data storage, and the anonymization of datasets to protect the dignity of participants. In Nigeria, where digital governance structures are still developing, these safeguards become even more critical. By embedding strong ethical principles in data collection and use, AI systems can gain the trust of the Deaf community and encourage greater adoption in educational and social contexts.

The social dimensions of AI and sign language integration emphasize empowerment and inclusion in everyday life.

For many Deaf individuals, exclusion is not only educational but also social, manifesting in limited access to employment, healthcare, and civic participation. AI-based interpretation tools and real-time translation services can significantly expand opportunities for social integration. According to Onyema and Hassan (2024), such innovations allow Deaf persons to access medical consultations, government services, and workplace interactions without depending solely on human interpreters. This enhances social autonomy and reduces stigmatization, enabling the Deaf to participate more fully in community and national development. Socially, therefore, AI strengthens equality by creating platforms where Deaf voices are visible and valued.

However, the rapid growth of AI also raises concerns about cultural preservation. Sign language is not just a communication tool but also a cultural marker of Deaf identity. The fear exists that overreliance on AI-generated speech translations could undermine the role of sign language as a cultural and social bond within Deaf communities. Umeh and Adeoti (2025) caution that while AI bridges communication with hearing societies, it

must not erode the unique cultural practices of Deaf people. Ethically, this means designing technologies that promote bilingualism—encouraging proficiency in both sign and spoken/written language—rather than replacing one with the other. Such an approach ensures that AI contributes to inclusion while preserving cultural identity.

Ethical and social implications extend to issues of equity in access to AI tools. Many of the most advanced sign language technologies remain expensive or inaccessible in developing nations. This digital divide risks excluding the very populations AI is meant to empower. As Nwankwo and Salami (2023) point out, inclusivity must go beyond technological capability to affordability, policy support, and infrastructural development. Governments, NGOs, and private sectors must collaborate to subsidize, localize, and distribute AI-based sign language technologies to ensure broad access. Socially, equitable access fosters collective development by ensuring that Deaf individuals are not left behind in the Fourth Industrial Revolution. Hence, ethical responsibility extends beyond design to

distribution, ensuring justice and equity in technology use.

Practical Applications in Education, Healthcare, and Employment

The practical applications of AI in relation to sign language are diverse and impactful, particularly in education, healthcare, and employment. In education, AI-based systems facilitate equal participation for Deaf students in classrooms by providing real-time sign-to-text or sign-to-speech translation. In healthcare, AI interpreters allow patients with hearing impairments to communicate effectively with medical professionals, thereby reducing risks associated with miscommunication. Employment sectors also benefit, as AI platforms can foster collaboration between Deaf and hearing employees by breaking down communication barriers. These applications emphasize the transformative nature of science when applied inclusively. According to Musa and Adeniran (2025), the use of AI in communication enhances productivity and participation in workplaces, demonstrating that inclusivity is not merely a social demand but an economic necessity. These practical benefits reinforce the argument that AI's

synergy with sign language is not a futuristic dream but a present reality that enhances the lives of millions globally.

In the educational sector, AI-powered sign language technologies are transforming access to teaching and learning for students with hearing impairments. Intelligent systems such as automated sign-to-text converters, virtual avatars, and AI-based captioning platforms help Deaf learners follow lessons in real time, reducing dependence on human interpreters. According to Adeyeye and Musa (2023), the integration of these tools into Nigerian classrooms not only fosters inclusivity but also enhances active participation and comprehension among Deaf students. Teachers also benefit from AI applications by accessing adaptive feedback on learners' progress, enabling them to refine instructional strategies. This shift illustrates how AI is bridging the gap between students with hearing impairments and their hearing peers, ensuring that inclusive education is not a mere policy statement but a lived reality in schools.

Healthcare represents another critical domain where AI applications in sign language

demonstrate immense value. Communication between Deaf patients and healthcare providers has historically been a challenge, often leading to misdiagnosis, inadequate treatment, or complete exclusion from services. AI-based interpretation systems, such as mobile applications and smart wearables, can translate sign language into spoken words for doctors and convert spoken responses into sign visuals for patients. Eneh and Balogun (2024) argue that such innovations are essential for equitable access to healthcare, particularly in Nigeria where interpreter services are scarce. With these tools, medical consultations become more accurate, patient-centered, and inclusive, reducing health disparities for individuals with hearing impairments. Scientifically, this demonstrates how AI supports health equity by ensuring communication barriers do not compromise human well-being.

In the realm of employment, AI has created new opportunities for Deaf individuals to participate in diverse professional environments. Real-time AI sign interpreters embedded in workplace software such as Zoom, Microsoft Teams, or Google Meet allow seamless communication during

meetings and collaborative tasks. Akinola and Odu (2025) highlight that by integrating these tools into workplace structures, employers not only comply with disability inclusion laws but also benefit from the creativity and productivity of Deaf employees. Furthermore, AI-driven training platforms customized with sign language accessibility features support professional growth, allowing Deaf workers to upskill and remain competitive in the labor market. This application underscores how AI reduces structural barriers to employment while advancing workplace diversity and innovation.

Beyond direct access, AI applications also foster empowerment by creating independent interaction channels. In education, this translates to students being able to access digital libraries and e-learning platforms without external mediation. In healthcare, patients can describe symptoms and receive instructions without misinterpretation. In employment, workers can independently execute roles requiring communication with clients or colleagues. According to Obinna and Yakubu (2022), such independence enhances confidence, reduces stigma, and

redefines how Deaf individuals navigate society. These applications not only solve immediate communication problems but also empower the Deaf community to engage in public spaces as autonomous citizens. The practical significance lies in the shift from dependency to agency, where AI becomes an enabler of independence.

Practical applications of AI in these sectors support broader developmental goals at both national and global levels. Education that integrates AI for Deaf learners aligns with the Sustainable Development Goal (SDG 4) of inclusive and equitable quality education. Healthcare innovations contribute to SDG 3 on ensuring healthy lives and promoting well-being for all. Employment inclusion resonates with SDG 8 on decent work and economic growth. As Bello and Idris (2023) note, aligning AI innovations with these goals ensures that the Deaf community is not left behind in the global push for sustainable development. By bridging education, healthcare, and employment, AI's synergy with sign language emerges as a transformative force for social justice, economic progress, and human dignity.

Conclusion

In conclusion, the evolving synergy between AI, science, and sign language illustrates how technological progress can redefine the relationship between knowledge, innovation, and inclusivity. AI demonstrates that science can go beyond laboratory achievements to embrace the lived realities of marginalized communities. Through gesture recognition, translation, and accessibility platforms, AI affirms that sign language is a fully recognized linguistic system deserving of computational modeling and societal integration. More importantly, the synergy reflects the broader mission of science as a human-centered endeavor where inclusivity, empathy, and justice shape innovation. As Nigerian scholars like Adebisi and Odetunde (2023) argue, sustainable development requires technologies that leave no one behind. Therefore, AI's integration with sign language is more than a technical advancement—it is a scientific and moral achievement that positions society closer to a future where communication is universal, education is inclusive, and equity is guaranteed.

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